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ARE THE TERMS *STIFFENING/SOFTENING STRUCTURES* MECHANICALLY UNAMBIGOUS?

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ABSTRACT

The purpose of this paper is to give a conditionally affirmative answer to the question posed in its title. The tool that enables such an answer is a mechanically objective arc-length, ξ. In this context, mechanical objectivity is defined as the independence of $\xi(\lambda)$, where λ denotes a dimensionless proportionality factor, of the chosen finite element and the discretization of the investigated structure in the framework of a consistent mesh refinement. It guarantees, e.g., the mechanical objectivity of the value of λ, for which $d^2\lambda/d\xi^2=0$, signaling the transition from a stiffening to a softening structure and vice versa. It is shown numerically that for this value of λ, $d^2\lambda/dq_i^2>0$ while $d^2\lambda/dq_j^2<0$, where qi and qj denote two characteristic degrees of freedom (d.o.f.) of the investigated structure. Hence, individual d.o.f. are, in general, unsuitable for marking extreme values of the stiffness of structures. A global quantity, alternative to the normalized stiffness $d\lambda/d\xi$, is $\det\mathbf{K}_T/\det(\mathbf{K}_T)_0$, where $\mathbf{K}_T$ and $(\mathbf{K}_T)_0$ denote the tangent stiffness matrix at an arbitrary load level and at the onset of loading, respectively. It is shown numerically that, in general, the values of λ for which $d(\det\mathbf{K}_T)/d\lambda=0$ do not correlate with the ones of extreme values of the stiffness of structures. In fact, extreme values of $\det(\mathbf{K}_T)$ usually have no physical meaning. Consequently, the decrease of $\det\mathbf{K}_T$, preceding the onset of buckling, need not signal a softening structure. An oblate rotational ellipsoidal shell, subjected to internal pressure, serves as an example for buckling of a stiffening shell.